Automatic compression control for the LCLS injector laser

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Introduction

For this project, I was asked to replace the manual linear compressor and cross-correlator stages in the Coherent 1 & 2 laser system at the Injector lab. The goal was to replace the manual stages with motorized stages to automatically control the compression of the laser pulses driving LCLS. In order to do this, we used SmarAct Piezo stages along with LabView software to write a program that controlled the stages. It was in LabView that we developed the double-motion VI to control both the compression and automatically correct for the subsequent timing changes. This upgrade was important because it allowed for a more streamlined design capable of producing efficient and reproducible compressions settings for the LCLS driving laser.

Description of Stages

We picked the Smaract piezo stages because of their precision, repeatability and stability properties. Moreover the very compact footprint of these stages allowed to take advantage of the full space in the compressors. The linear stages, SLLA42-190-M-E and SLLA42-270-M-E were procured during the previous shutdown and were ready for testing and install at the beginning of this shutdown.

The stages and hand controller are shown below (Fig.1-2). We needed two stages, a short one (SLLA42-190-M-E) inside the compressor at the retroreflector position, and a long one (SLLA42-270-M-E) outside as a delay line to correct for timing changes. See schematics of the setup in Fig.2. To begin, we measured the compressor enclosure and its limits, which gave us an idea of how to mount and arrange the new stages. Once that was finished, we began indexing the older, manual stages so that we didn't have to waste as much time in the alignment process.

Fig. 1: SmarAct Motorized Linear Stage

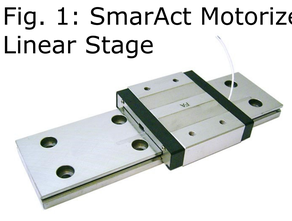
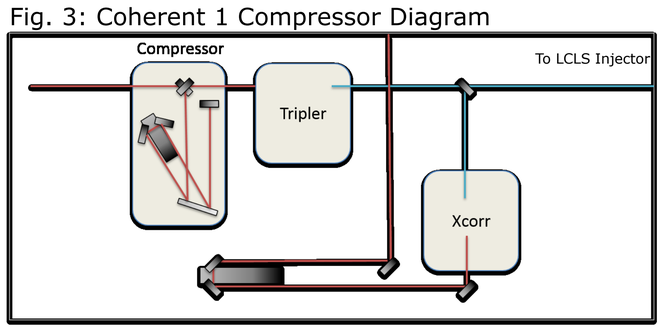


Fig 2. SmarAct MCS-3 Controller

Fig. 3: Coherent 1 Compressor Diagram



Software Development

With both stages mounted, we installed the controller, connected it up to the computer, and began developing our control software through LabView.

This was the most time consuming part, because we had to develop our own LabView software to perform combined motion of two stages. One for compression, the other for time of arrival correction. Taking the SmarAct/LabView package as starting point, we began coding our program. After a few hiccups, controller setting changes, etc, we were able to get both stages moving.

Once this was achieved, we added some basic presets in so that whoever is using the lab can save the different timings she/he desires [ex. Full compression, 1ps, 2ps, etc].

Finally, we needed to do some last minute touch-ups in the software to promote longevity. Most importantly, was fixing the problem that came when the controller is turned off. If the controller is turned off for some reason [accident, power outage, etc] the stage loses its reference, rendering the presets useless. To fix this, we programmed the stages to have a manual reference/calibrate as preventative maintainance. By doing so, the user can rely on her/his presets to be accurate, even if the controller is turned off.

Fig. 4: Front Panel for LabView Program

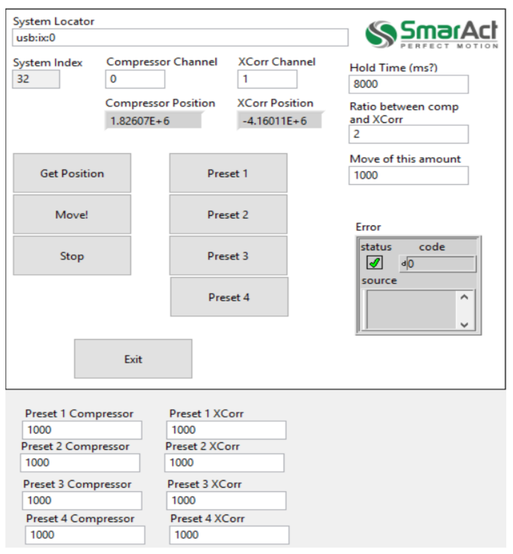
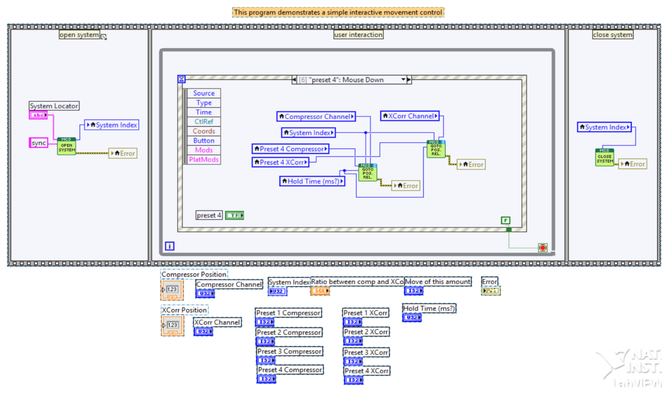


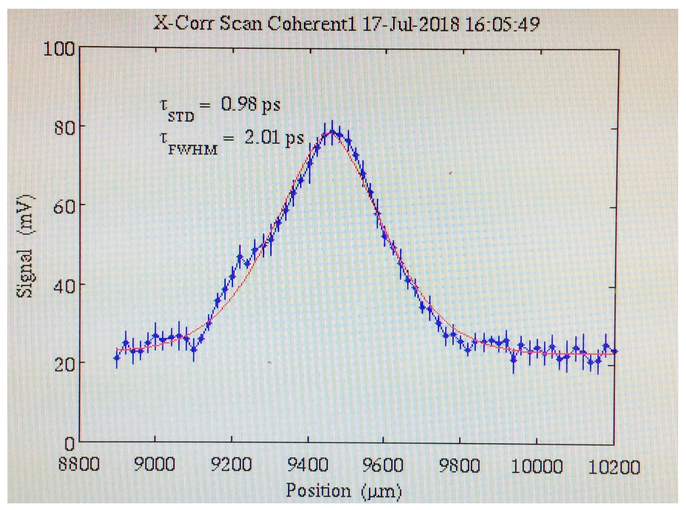
Fig. 5: Block Diagram for LabView Program



Results

The diagram below (Fig. 4) is an example of a 2ps cross-correlation between the 800nm oscillator beam and the UV output beam of the tripler. In order to test the accuracy of the presets in LabView, we did similar tests for 1ps, 1.5ps, and full compression measurements. After switching between the presets we were able to maintain consistency between measurements.

Fig. 6: Cross-correlator curve for 2ps setting



Conclusions

By using these motorized SmarAct stages, we can streamline operations in a few key ways. These stages are capable of precise movement, retaining preset timings, and double motion between the compressor and cross-correlator. Optimizing compression is now much faster because of this upgrade. Further, the testing done in the injector lab with these stages can provide us with data to determine whether these stages are suitable for mass use in the development of LCLS II.

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